Constant-Head Well Testing in Support of Environmental Remediation

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RESEARCH OBJECTIVES

Groundwater contamination resulting from improper waste disposal and accidental releases of chemicals to the environment is a significant problem faced by many communities. Numerous technologies have been developed over the past two decades to treat contaminated groundwater. Selection of the best-available technology for a given site is based on the treatment technology's ability to either remove or immobilize the contaminant and the cost of implementing the treatment. Both criteria are typically evaluated in light of contaminant travel times, which influence the groundwater treatment time and cost, thus potentially affecting the final cleanup method selected. This article describes a constant-head test method and equipment used in the field to estimate relatively low hydraulic conductivities (K), an important hydrological property of the contaminated water-bearing zone used to estimate travel times.

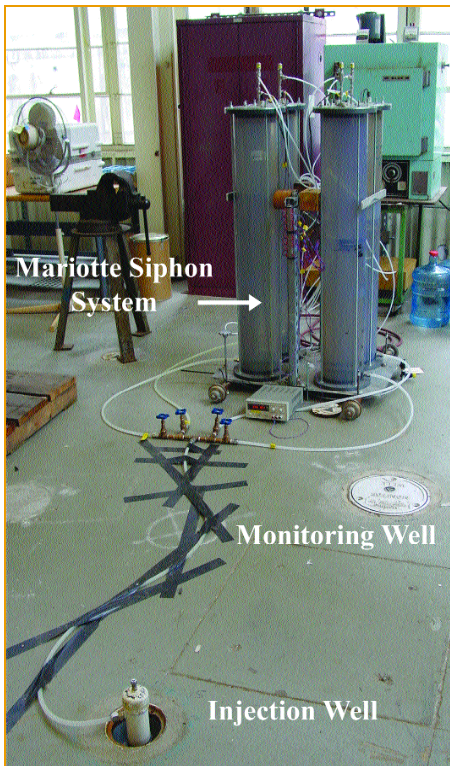

Figure 1. Photo of pressurized Mariotte siphon system and constant-head test configuration

APPROACH

A variety of methods are employed to measure K in the field. During a typical pumping test, groundwater is pumped from a well penetrating the desired zone at a constant rate, and the change in water levels is monitored in nearby wells. Alternatively, during a slug test, groundwater may be quickly added to or removed from a well, and the water level in the test well is monitored as it returns to its original level. Both techniques have their advantages and disadvantages. Pumping tests are difficult to perform in low K formations because the pumping rate may exceed the yield of the aquifer, causing the well to be pumped dry. The stress applied to the aquifer during a slug test typically penetrates only a short distance into the adjacent formation, suggesting the measured K may be influenced by conditions near the borehole (e.g., formation damage caused by drilling). The method presented here employs a specially designed Mariotte siphon system (Figure 1) to maintain a constant-hydraulic head on the test well during water injection. Observed changes in flow rate and water levels are used to estimate K.

ACCOMPLISHMENTS

Our equipment (Figure 1) differs from what is typically employed, which includes disc and Guelph permeameters, in that the test vessel is constructed to withstand higher working pressures and, therefore, can be operated at pressures exceeding one atmosphere (zero gauge pressure). This allows the test operator to deliver water to the well at a constant positive head up to 3 atmospheres (gauge) by connecting compressed air to the bubble tube instead of leaving it open to the atmosphere.

SIGNIFICANCE OF FINDINGS

The test equipment was successfully used to conduct a constant-head injection test lasting 60 days in duration. During this time period, water levels in adjacent observation wells, located up to 4.6 m from the injection point, increased by 0.3 to 1 m because of the 5.2 m injection head. Analysis of the test results produced estimates of K comparable to those produced from baseline slug tests conducted on the same wells. Constant-head tests have an advantage over pump tests in that they can be used to characterize low-yield porous materials. Compared to slug tests, this method stresses a much larger volume of the zone of interest, producing estimates of K that are less susceptible to error caused by wellbore damage and, therefore, more representative of the formation.

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